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(11) **EP 0 928 680 A1**

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
14.07.1999 Bulletin 1999/28

(51) Int. Cl.<sup>6</sup>: B29D 30/16, B29D 30/48

(21) Application number: 97830731.2

(22) Date of filing: 30.12.1997

(84) Designated Contracting States:  
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC  
NL PT SE  
Designated Extension States:  
AL LT LV MK RO SI

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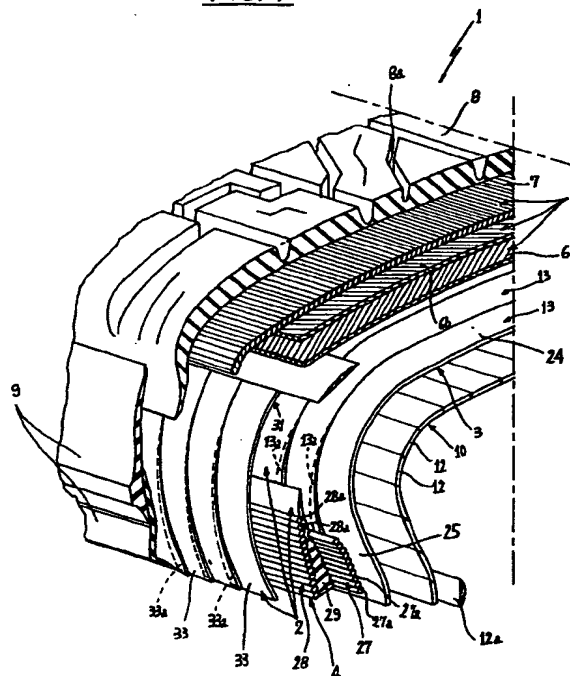
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### (54) A method for making tyres for vehicle wheels

(57) A first carcass ply (3) is formed by depositing onto a toroidal support (11), strip-like lengths (13) cut to size from a continuous strip-like element and each comprising longitudinal thread-like elements (14) incorporated into a layer of elastomer material (17). The strip-like lengths are laid down sequentially in mutual circumferential side by side relationship, to form side portions (25) partly superposed on each other and crown portions (24) in mutual circumferential side by side relationship. Associated with the carcass ply (3) are annular structures (4) comprising a first and a second circumferentially inextensible annular inserts (27, 28) and an elastomer filling (29) interposed therebetween. A second carcass ply (31) is made in superposed position to the first carcass ply (3) and the annular structures (4). A belt structure (5), a tread band (8) and sidewalls (9) are combined with the carcass structure (2) thus formed, to define a tyre (1) to be vulcanized.

FIG. 1



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## Description

[0001] The present invention relates to a method of making tyres for vehicle wheels, comprising the steps of: manufacturing a carcass structure; optionally associating a belt structure with the carcass structure at a circumferentially external position thereof; associating a tread band with the belt structure at a circumferentially external position thereof; associating at least one pair of sidewalls with the carcass structure at laterally opposite positions; vulcanizing the obtained tyre.

[0002] Manufacture of tyres for vehicle wheels involves formation of a carcass structure essentially consisting of one or more carcass plies substantially having a toroidal conformation and the axially opposite side edges of which engage respective circumferentially inextensible annular reinforcing elements called "bead cores".

[0003] Applied to the carcass structure, at a circumferentially external position thereof, is a belt structure comprising one or more belt strips in the form of a closed ring, essentially consisting of textile or metal cords suitably oriented relative to each other and to the cords belonging to the adjacent carcass plies.

[0004] A tread band currently consisting of a strip of elastomer material of appropriate thickness is applied to the belt structure, at a circumferentially external position thereof.

[0005] It is to point out that, to the aims of the present invention, by the term "elastomer material" it is intended a rubber blend in its entirety, that is the assembly made up of a base polymer suitably amalgamated with mineral fillers and/or additives of any other type.

[0006] Finally, to the opposite sides of the tyre being manufactured a pair of sidewalls are applied, each of them covering a side portion of the tyre included between a so-called shoulder region, located close to the corresponding side edge of the tread band, and a so-called bead located at the corresponding bead core.

[0007] In accordance with traditional production methods, essentially the above listed tyre components are first made separately from each other to be then assembled during a tyre-manufacturing step.

[0008] For instance, for making the carcass ply or plies to be associated with the bead cores to form the carcass structure, production of a rubberized fabric comprising longitudinally-disposed continuous textile or metallic cords, through an extrusion and/or calendering process, is first required. This rubberized fabric is submitted to a transverse-cutting operation to produce lengths of predetermined sizes that are subsequently joined together so as to give rise to a continuous ribbon-like semifinished product having transversely-disposed parallel cords.

[0009] Then this article of manufacture is to be cut into pieces the length of which is correlated with the circumferential extension of the carcass to be made.

[0010] Production methods have been recently pro-

posed which, instead of resorting to the production of semifinished products, make the carcass structure directly during the tyre-manufacturing step.

[0011] For example, US Patent 5,453,140 herein quoted as an example of the most pertinent state of the art, discloses a method and an apparatus forming a carcass ply starting from a single cord previously wound around a reel.

[0012] According to the method and apparatus described in the above patent, at each operating cycle of the apparatus the cord drawn from the reel by power-driven idler rollers and maintained taut by a pneumatic tensioning system is cut to size to obtain a length of pre-established extension.

[0013] The cord length is picked up by a pick-up element mounted on a belt wound over power-driven pulleys to be extended transversely on the outer surface of a toroidal support.

[0014] The length ends are then engaged by bending members of the belt type operating on the opposite sides of the toroidal support for radially applying the cord length to the toroidal support by means of slide elements acting like fingers along the side portions of the cord length.

[0015] Repetition of the above described operating cycle leads to deposition of a number of cord lengths circumferentially disposed in side by side relationship until the whole circumferential extension of the toroidal support has been covered.

[0016] Necessarily, the toroidal support is previously coated with a layer of raw rubber having a dual function, i.e. that of adhering to the cords deposited thereon so as to conveniently hold them in a fixed positioning, and that of constituting an air-proof inner liner in the finished tyre.

[0017] Tyres obtained by this production method have a carcass structure in which the carcass ply or plies consist of individual cords each having two side portions axially spaced apart from each other and oriented radially of the rotation axis of the tyre, and a crown portion extending at a radially outer position between the side portions.

[0018] Within the scope of the carcass structure manufacture, it is also known that close to each of the tyre beads, the opposite ends of the individual cords forming a carcass ply are arranged, in an alternating sequence, at axially opposite positions relative to an annular anchoring element forming said bead core, as can be learnt from patent EP 0 664 231.

[0019] In accordance with the present invention, within the tyre-manufacturing scope remarkable advantages have been found to be achieved if the carcass ply or plies are made by depositing strip-like lengths instead of individual cords, each of said lengths essentially comprising a layer of raw elastomer material incorporating two or more parallel thread-like elements disposed longitudinally.

[0020] In more detail, the invention relates to a

method of making a tyre for vehicle wheels, characterized in that manufacturing of the carcass structure involves formation of at least one first carcass ply by the following steps: preparing strip-like lengths each comprising longitudinal and parallel thread-like elements at least partly coated with at least one layer of raw elastomer material; depositing each of the strip-like lengths onto a toroidal support in a substantially U-shaped conformation around the cross section profile of the toroidal support, to define two side portions substantially extending in planes orthogonal to a geometric axis of rotation of the toroidal support at mutually spaced apart positions in an axial direction, and a crown portion extending at a radially outer position between the side portions, wherein the crown portions of each strip-like length are consecutively disposed in side by side relationship along the circumferential extension of the toroidal support, whereas the side portions of each strip-like length are each partly covered with a side portion of at least one circumferentially consecutive length.

[0021] Preferably, preparation of said strip-like lengths is carried out by cutting actions executed sequentially on at least one continuous strip-like element incorporating said thread-like elements in said layer of raw elastomer material.

[0022] In addition, each cutting action is preferably provided to be followed by deposition of the individual length thus obtained onto the toroidal support.

[0023] In more detail, the side portions belonging to circumferentially contiguous lengths on the toroidal support are caused to mutually converge towards the geometric axis of rotation of the toroidal support itself.

[0024] Advantageously, covering of the side portions of the strip-like lengths progressively decreases starting from a maximum value at radially inner ends of the side portions until a zero value at transition regions between said side portions and crown portions.

[0025] In a preferential solution the individual strip-like lengths are sequentially deposited onto the toroidal support according to a circumferential distribution pitch corresponding to the width of the strip-like element.

[0026] In accordance with a possible alternative embodiment, the individual strip-like lengths are sequentially deposited onto the toroidal support according to a circumferential distribution pitch corresponding to a multiple of the width of the strip-like element.

[0027] Preferably, each strip-like length has a width corresponding to a submultiple of the circumferential extension of the toroidal support, as measured at an equatorial plane thereof.

[0028] According to a further aspect of the invention, accomplishment of said at least one first carcass ply further involves a step of sequentially pressing the strip-like element at its side portions, to define regions of increased width close to the inner circumferential edges of the carcass structure.

[0029] Said pressing step can be optionally carried out on the continuous strip-like element before execut-

ing the cutting action.

[0030] Concurrently with said pressing step, moving apart from each other of the thread-like elements comprised in the strip-like element is carried out.

[0031] During the deposition step, at least one of the strip-like lengths may be advantageously held on the toroidal support by a suction action produced through the toroidal support.

[0032] In particular, formation of each strip-like length involves the steps of: laying down the strip-like length transversely and at a centred position relative to an equatorial plane of the toroidal support; radially moving the strip-like length close to the toroidal support so as to form the crown portion of the length on the toroidal support; translating the opposite ends of the strip-like length substantially radially close to the geometric axis of rotation of the toroidal support for applying the side portions of the strip-like length to the toroidal support; rotating the toroidal support relative to the distributor element through an angular pitch corresponding to the circumferential distribution pitch of the strip-like lengths.

[0033] A step of pressing said side portions of the strip-like lengths against the side walls of the toroidal support may be also provided.

[0034] Advantageously, accomplishment of the carcass structure further comprises the step of applying at least one inextensible annular structure to a region close to each of the inner circumferential edges of the carcass ply obtained from the deposition step.

[0035] According to a possible embodiment, accomplishment of the carcass structure further comprises the step of forming a second carcass ply superposed on the first carcass ply and the circumferentially inextensible annular structures.

[0036] Formation of the second carcass ply may advantageously take place in the same manner as accomplishment of the first carcass ply.

[0037] Formation of the carcass ply or plies may be preceded by a step of coating the toroidal support with at least one liner made of an air-proof elastomer material.

[0038] This coating step is advantageously carried out by winding at least one ribbon-like band of an air-proof elastomer material in coils disposed side by side along the cross section profile of the toroidal support.

[0039] In addition to, or in place of formation of the liner, the following steps may be provided to be carried out before the vulcanization step: disengaging the tyre from the toroidal support; introducing an air tube into the carcass structure.

[0040] During said vulcanization step, a step of stretching said carcass plies and belt strips may be advantageously carried out for achieving an expansion of the tyre of a linear amount included between 2% and 5%.

[0041] In accordance with a further innovatory aspect of the invention, to be advantageously adopted also independently of the innovatory features set out herea-

bove, accomplishment of each inextensible annular structure comprises the steps of: depositing at least one first elongated element in concentric coils into a moulding cavity in view of forming a first circumferentially inextensible annular insert substantially in the form of a crown; depositing at least one second elongated element in concentric coils into the moulding cavity in view of forming a second circumferentially inextensible annular insert substantially in the form of a crown coaxially disposed in side by side relationship relative to the first annular insert; forming at least one filling body of raw elastomer material in the moulding cavity, which filling body is interposed between, and intimately joined to the first and second circumferentially inextensible annular anchoring elements.

[0042] Each of the inextensible annular structures made as above described may be conveniently provided to be interposed between the first carcass ply and the second carcass ply.

[0043] Each of said deposition steps of the first and/or second elongated element can be conveniently preceded by a rubberizing step in which said first and/or second elongated element is coated with at least one layer of raw elastomer material.

[0044] Preferably, also provided is a step of magnetically retaining the first and/or second circumferentially inextensible annular insert, at a predetermined position, within the moulding cavity.

[0045] Formation of said filling body may advantageously comprise the steps of: interposing at least one annular element of raw elastomer material of a predetermined volume between the first and second inextensible annular inserts; reducing the volume of the moulding cavity in order to compress said annular element of elastomer material between the first and second inextensible annular inserts and deform it until it fills said moulding cavity.

[0046] Further features and advantages will be best understood from the detailed description of a preferred but non-exclusive embodiment of a method of manufacturing a tyre for vehicle wheels according to the present invention. This description will be taken hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 is a fragmentary splitted perspective view of a tyre in accordance with the present invention;
- Figs. 2 to 5 diagrammatically show an apparatus for making the carcass ply, according to different operating steps respectively, seen in a direction orthogonal to a diametrical section plane of a toroidal support carrying the tyre during the manufacturing step;
- Fig. 6 is a diagram showing manufacture of a continuous strip-like element intended for forming the carcass ply or plies;
- Fig. 7 shows an embodiment of said strip-like element in cross section;

- Fig. 8 is a fragmentary perspective view diagrammatically showing the deposition sequence of strip-like lengths for the purpose of forming a first carcass ply of the tyre in accordance with the invention;
- Fig. 9 is a fragmentary diametrical section view of an inextensible annular structure to be inserted at the tyre bead, during a moulding step for manufacturing the tyre;
- Fig. 10 is a fragmentary perspective view of an inextensible annular structure laterally applied between a first and a second carcass plies;
- Fig. 11 is a diagram showing the carcass structure of a tyre in accordance with the invention, seen laterally and in transparency for highlighting the mutual arrangement of the portions in superposed relationship of the individual strip-like lengths belonging to two different carcass plies;
- Fig. 12 is a cross half-section showing a conventional tyre mounted on a respective mounting rim and in a condition of slip running and partial deflation;
- Fig. 13 is a cross half-section showing a tyre according to the invention mounted on a respective mounting rim and in a condition of slip running and partial deflation.

[0047] With reference to the drawings, a tyre for vehicle wheels made by a method according to the present invention has been generally identified by reference numeral 1.

[0048] Tyre 1 essentially comprises a carcass structure 2 having at least one first carcass ply 3 having a substantially toroidal conformation and in engagement, by its opposite circumferential edges, with a pair of inextensible annular structures 4, each of which is located, when the tyre has been completed, at the region usually identified as "tyre bead".

[0049] Applied to the carcass structure 2 at a circumferentially outer position thereof, is a belt structure 5 comprising one or more belt strips 6a, 6b and 7. A tread band 8 is circumferentially superposed on the belt structure 5 and longitudinal and transverse cuts 8a are formed in said tread band 8, following a moulding operation carried out concurrently with the tyre vulcanization, and such disposed as to define a desired "tread pattern".

[0050] The tyre also comprises a pair of so-called "sidewalls" 9 laterally applied to opposite sides of the carcass structure 2.

[0051] The carcass structure 2 may possibly be coated, on its inner walls, with a liner 10, essentially consisting of a layer of air-proof elastomer material, suitable to ensure the hermetic seal of the inflated tyre.

[0052] Assembling of the above listed components, as well as production of one or more of said components, takes place with the aid of a toroidal support 11, diagrammatically shown in Figs. 2 to 5, having the same

configuration as the inner walls of the tyre to be manufactured.

[0053] In a preferential solution the toroidal support 11 has reduced sizes relative to those of the finished tyre, according to a linear amount preferably included between 2% and 5%, measured, just as an indication, along the circumferential extension of the support itself at an equatorial plane X-X thereof which is coincident with the equatorial plane of the tyre.

[0054] The toroidal support 11, which is not described or illustrated in detail in that it is not particularly of importance to the purposes of the invention, may for example consist of a collapsible drum or an inflatable bladder suitably reinforced, so that it may take and maintain the desired toroidal conformation under inflation conditions.

[0055] After taking into account the above statements, manufacture of tyre 1 first involves formation of the carcass structure 2 starting with possible formation of the liner 10.

[0056] This liner 10 can be advantageously made by circumferentially winding around the toroidal support 11, at least one ribbon-like band 12 of an air-proof elastomer material, produced from an extruder and/or a calender located close to the toroidal support itself. As viewed from Fig. 1, winding of the ribbon-like band 12 substantially takes place in circumferential coils consecutively disposed in side by side relationship to follow the cross section profile of the outer surface of the toroidal support 11.

[0057] For descriptive purposes, by "cross section profile" it is herein intended a configuration exhibited by the half-section of the toroidal support 11 sectioned along a plane radial to a geometric rotation axis thereof, not shown in the drawings, which is coincident with the geometric axis of rotation of the tyre being manufactured.

[0058] Concurrently with winding of the ribbon-like band 12, application of a pair of auxiliary annular elements 12a can be carried out close to the inner circumferential edges of the carcass structure during its manufacturing step. Each of these auxiliary annular elements 12a can be obtained for example by winding the ribbon-like band 12 in a coil axially disposed in side by side relationship with the corresponding coil located at the inner perimetric edge of liner 10 defined or to be defined on the toroidal support 11. Alternatively, the auxiliary annular elements 12a can be made up of at least one auxiliary ribbon-like band obtained from a respective extruder located at the toroidal support 11.

[0059] In accordance with the present invention, the carcass ply 3 is directly formed on the toroidal support 11 by depositing thereon, as better clarified in the following, a plurality of strip-like lengths 13 obtained from at least one continuous strip-like element 2a preferably having a width included between 3 mm and 20 mm.

[0060] As shown in Fig. 6, preparation of the continuous strip-like element 2 essentially involves that two or more thread-like elements 14, and preferably three to

ten thread-like elements 14, fed from respective reels 14a, should be guided through a first extruder 15 associated with a first extrusion apparatus 16 carrying out feeding of raw elastomer material through the extruder itself.

[0061] It is pointed out that, in the present description by "extruder" it is intended that part of the extrusion apparatus, also identified in this particular field by the term "extrusion head", provided with a so-called "die" passed through by the product being worked at an outlet port shaped and sized according to the geometrical and dimensional features to be given to the product itself.

[0062] The elastomer material and thread-like elements 14 are intimately joined together within the extruder 15, thereby generating the continuous strip-like element 2a at the outlet thereof, which element is formed of at least one layer of elastomer material 17 in the thickness of which the thread-like elements themselves are incorporated.

[0063] Depending on requirements, it is possible to guide the thread-like elements 14 in the extruder 15 in such a manner that they are not integrally incorporated into the layer of elastomer material 17 but appear on one or both surfaces thereof.

[0064] The thread-like elements 14 may each consist for example of a textile cord preferably having a diameter included between 0.6 mm and 1.2 mm, or a metallic cord preferably having a diameter included between 0.3 mm and 2.1 mm.

[0065] Advantageously, if required, the thread-like elements 14 can be disposed in the continuous strip-like element 2a in such a manner that they give the carcass ply 3 thus obtained unexpected qualities of compactness and homogeneity. For the purpose, the thread-like elements 14 can be for example disposed according to a density greater than six thread-like elements/centimetre, measured circumferentially on the carcass ply 3 close to the equatorial plane X-X of tyre 1. In any case it is preferably provided that the thread-like elements 14 should be disposed in the strip-like element 2a according to a mutual distance between centres not lower than 1.5 times the diameter of the thread-like elements themselves, in order to enable an appropriate rubberizing operation between the adjacent threads.

[0066] The continuous strip-like element 2a coming out of extruder 15 can be advantageously guided, optionally through a first accumulator-compensator device 18, on a deposition apparatus 19 diagrammatically shown in Figs. 2 to 5.

[0067] The deposition apparatus 19 essentially comprises first guide members 20, consisting for example of a pair of opposite rollers intended for engagement of the continuous strip-like element 2a produced by the extruder 15, downstream of the accumulator-compensator device 18.

[0068] Downstream of the first guide members 20, the strip-like element 2a comes into engagement with a first

grip member 21 movable in a direction oriented transversely to the equatorial plane X-X of the toroidal support 11.

[0069] In more detail, the first grip member 21 is movable between a first operating position in which, as shown in Fig. 2, it engages one end of the continuous strip-like element 2a close to the first guide members consisting of opposite rollers 20, and a second operating position in which, as shown in Fig. 3, it is moved apart from the first guide member in order to lay down the continuous strip-like element 2a transversely of the equatorial plane X-X of the toroidal support 11.

[0070] When the first grip member 21 has reached the second operating position, a second grip member 22 engages the continuous strip-like element 2a close to the first guide members 20.

[0071] Then, a cutting member 23 is applied, to cut the continuous strip-like element 2a at a stretch thereof included between the second grip element 22 and the first guide members 20, giving rise to formation of a strip-like length 13 of a predetermined extension "L".

[0072] Following the cutting action by the cutting member 23, the obtained strip-like element 13 is laid down transversely and at a centred position relative to the equatorial plane of the toroidal support.

[0073] Afterwards, the grip members 21 and 22 are simultaneously translated in the direction of the geometric axis of the toroidal support 11 by radially moving the strip-like length 13 close to the toroidal support. Under this circumstance, formation of a crown portion 24 takes place at a centred position on the longitudinal extension of the strip-like length 13, which portion extends at a radially outer position on the toroidal support 11.

[0074] As clearly viewed from Fig. 4, as the radial movement of the grip members 21 and 22 goes on the opposite ends of the strip-like length 13 are moved radially close to the geometric axis of rotation of the toroidal support 11, giving rise to formation of two side portions 25 substantially extending in planes orthogonal to the geometric axis of rotation of the toroidal support, at positions axially spaced apart from each other.

[0075] By a possible subsequent movement of the grip members 21 and 22 close to the toroidal support 11, the opposite ends of the strip-like element are definitively applied to the toroidal support 11 so that deposition of length 13 is completed, this length taking a substantially U-shaped configuration around the cross section profile the toroidal support.

[0076] Components intended for support and guided movement of the grip members 21 and 22 are not shown in the accompanying drawings as they can be made in any manner convenient for a person skilled in the art, and in any case they are not of importance to the aims of the present invention.

[0077] If required, the side portions 25 of the strip-like length can be submitted to a pressing step against the side walls of the toroidal support 11. For the purpose, a pair of pressing rollers or equivalent means not shown

may be provided for operation on the opposite sides of the toroidal support 11, which rollers are each arranged to act on the respective side portion 25 by a thrust action and simultaneous radial sliding towards the geometric axis of rotation of the toroidal support 11.

[0078] Due to the sticky character of the raw elastomer material forming layer 17 coating the thread-like elements 14, a steady adhesion of the strip-like length 13 to the surfaces of the toroidal support 11 is ensured, even in the absence of liner 10 on said toroidal support. In more detail, the above described adhesion takes place as soon as the strip-like length 13 comes into contact with the toroidal support 11 at a radially external region of its cross section profile.

[0079] In addition to, or in place of the above described exploitation of the natural sticky character of the elastomer material, holding of one or more strip-like lengths 13 on the toroidal support 11 can be obtained by carrying out a suction action produced through one or more appropriate holes 26 arranged on the toroidal support.

[0080] The toroidal support 11 can be driven in angular rotation according to a step-by-step movement in synchronism with operation of the deposition apparatus 19, in such a manner that at each cutting action of each strip-like length 13 deposition of the latter onto the toroidal support takes place in a circumferential side by side relationship with the strip-like length 13 previously deposited.

[0081] In the embodiment diagrammatically shown in the accompanying figures, where the circumferential distribution pitch of the individual strip-like lengths 13 corresponds to the width of same, the angular-rotation pitch of the toroidal support 11 will correspond to the width of said lengths.

[0082] However, the circumferential distribution pitch of the strip-like lengths 13 may be provided to correspond to a multiple of their width. In this case, the angular-movement pitch of the toroidal support 11 will correspond to said circumferential distribution pitch. It is to point out that, to the aims of the present invention, when it is not otherwise stated, the term "circumferential" refers to a circumference lying in the equatorial plane X-X and close to the outer surface of the toroidal support 11.

[0083] Due to the above described operating sequence of the deposition apparatus 19, in the first carcass ply 3 obtained the crown portions 24 of each strip-like length 13 are consecutively disposed in side by side relationship along the circumferential extension of the toroidal support 11, whereas each of the side portions 25 of each length 13 is partly superposed with the side portion 25 of at least one length 13 previously laid down, and also partly covered with the side portion 25 of at least one length 13 laid down subsequently. In the accompanying figures, the overlapping regions of the strip-like lengths 13 forming the first carcass ply 3 are identified by 13a.

[0084] As clearly shown in Fig. 8, the side portions 25 in mutual superposition relationship move towards each other substantially in the direction of the geometric axis of rotation of the toroidal support 11, at an angle  $\delta$  the value of which is correlated with the width "W" of the strip-like elements 13, and in any case with the circumferential distribution pitch thereof, as well as with the value of a maximum radius R to be measured at a point of maximum distance from the geometric axis of rotation of the toroidal support 11.

[0085] Due to the mutual convergence between the contiguous side portions 25, mutual superposition or covering of same, i.e. the circumferential width of the overlapping regions 13a, progressively decreases starting from a maximum value at the radially inner ends of the side portions, until a zero value at the transition region between the side portions 25 and crown portions 24.

[0086] It is to note that, due to the difference between the maximum radius R and a minimum radius R', to be measured at a point of minimum distance from the geometric axis of rotation of the toroidal support 11, the average density of the thread-like elements 14, i.e. the amount of the thread-like elements 14 present in a circumferential section of given length, progressively increases on moving close to said geometric rotation axis.

[0087] In fact, this increase in density is proportional to the ratio value between the maximum radius R and minimum radius R'.

[0088] It is also to note that the thread-like elements 14 belonging to two mutually superposed side portions 25 are disposed in respectively crossed orientations at an angle corresponding to said angle  $\delta$ , in correlation with the width of the individual lengths 13 and their circumferential distribution pitch as well as with the value of the maximum radius R.

[0089] If, depending on requirements, one wishes to modify the crossing angle of the thread-like elements 14, a pressing step may be provided to be executed on the continuous strip-like element 2a in the regions of its longitudinal extension corresponding to the ends of the strip-like elements 13 to be obtained from said cutting actions. In this manner regions of greater width located at the inner circumferential edges of the formed carcass ply 3 are defined on the extension of each strip-like length 13.

[0090] Said pressing action can be carried out by said guide rollers 20 or by an auxiliary pressing roller (not shown) suitable to press the continuous strip-like element 2a in order to cause pressing of same at the longitudinal-extension sections intended to form the side portions 25 of the individual lengths 13. The pressing action causes a reduction in the thickness of the elastomer layer 17 and an increase in the width of the strip-like element 2a which, as a result, will make the thread-like elements 14 move apart from each other.

[0091] By suitably inclining the orientation of the geo-

metric axis of rotation of the toroidal support 11 relative to the movement direction of the first grip member 21 a desired inclination can be given to the crown portions 24 of lengths 13, included by way of example, between 0° and 25° relative to a radial plane passing by the geometrical axis. In more detail, this inclination may be advantageously included between 0° and 3° if tyre 1 is provided with only one carcass ply 3, or between 10° and 20°, and more preferably it may correspond to 15° if, as provided in the embodiment herein illustrated, the carcass structure is comprised of two carcass plies 3, 31.

[0092] Accomplishment of a carcass structure 2 generally comprises the step of applying said inextensible annular structure 4 to an area close to each of the inner circumferential edges of the carcass ply 3 obtained in the previously described manner, for the purpose of creating the carcass regions known as "beads", which are specifically intended for ensuring anchoring of the tyre to a corresponding mounting rim; in accordance with a preferred embodiment of the tyre, the carcass ply thereof is obtained in the above described manner.

[0093] Each of said inextensible annular structures 4 (Fig. 10) comprises a first circumferentially inextensible annular insert 27, substantially in the form of a crown concentric with the geometric axis of rotation of the toroidal support 11 and located close to a corresponding inner circumferential edge of the first carcass ply 3.

[0094] The first annular insert 27 is made of at least one elongated metal element wound up to form several substantially concentric coils 27a. Coils 27a can be defined by a continuous spiral or by concentric rings formed of respective elongated elements.

[0095] Combined with the first annular insert 27 is a second circumferentially inextensible annular insert 28 substantially extending in the form of a respective crown coaxially disposed in side by side relationship with the first annular insert 27.

[0096] The second annular insert 28 too is preferably made of at least one elongated metal element wound up to form several substantially concentric coils 28a that can be defined by a continuous spiral or by concentric rings formed of respective elongated elements.

[0097] Preferably, the second annular insert 28 has a radial extension given by the difference between the minimum inner radius and the maximum outer radius of the annular insert, which is greater than the radial extension of the first annular insert 27.

[0098] Interposed between the first and second annular inserts 27, 28 is at least one filling body 29 of elastomer material preferably having a hardness included between 70° and 92° Shore A.

[0099] As better clarified in the following, during the tyre use the above described annular structures 4 efficiently counteract tendency of the beads to rotate around their resting points on the rim under the effect of slip thrusts directed parallelly to the rotation axis of tyre 1. This tendency to rotation is particularly apparent

when the tyre is employed under conditions of partial or complete deflation.

**[0100]** Preferably, accomplishment of each annular structure 4 involves formation of a first inextensible annular insert 27 within a moulding cavity 30 defined in a mould 30a, 30b, by deposition of at least one elongated element in concentric coils 27a disposed in mutual side by side relationship according to circumferences of increasingly growing diameter around their geometric winding axis, corresponding to the rotation axis of the tyre.

**[0101]** This operation can be advantageously carried out through winding of the elongated element in a helical seating arranged in a first cheek 30a of the mould 30a, 30b which can be driven for the purpose in rotation around its own geometric axis.

**[0102]** Then, within the moulding cavity 30, a second annular insert 28 is located, formation of which can advantageously take place in the same manner as described for the first annular insert 27.

**[0103]** The deposition step of the elongated element or elements intended for formation of one or both annular inserts 27, 28 can be advantageously preceded by a rubberizing step during which the elongated element, preferably of metal material, is coated with at least one layer of raw elastomer material that not only ensures an excellent rubber-metal bond on the elongated element itself, but also promotes adhesion thereof for a steady placement in the above mentioned helical seating.

**[0104]** The first cheek 30a and/or the second cheek 30b may be also advantageously provided to be made of a magnetic material, or to be activated in an electromagnetic manner so as to conveniently attract and retain the respective elongated element, thereby ensuring a steady positioning of coils 27a and/or 28a as they are formed.

**[0105]** Then, the filling body 29 is formed within the moulding cavity 30. Forming of said body may be conveniently carried out by interposing at least one annular element of raw elastomer material of predetermined volume between the first and second annular inserts 27, 28 formed on the respective cheeks 30a, 30b. This annular element can have any convenient cross section conformation, provided that its volume corresponds to the inner volume of the moulding chamber 30 when cheeks 30a, 30b are moved close to each other in a closed condition of the mould.

**[0106]** Once the annular element has been positioned between cheeks 30a, 30b closure of the moulding cavity 30 by mutual approaching of the cheeks is carried out. Under this circumstance, the volume of the moulding cavity 30 is reduced, so that the annular element of raw elastomer material is pressed between the first and second annular inserts 27, 28 being submitted to deformation until it completely fills the moulding cavity, thereby forming the filling body 29 which is intimately joined to the first and second annular inserts 27, 28.

**[0107]** As an alternative solution to the above, forma-

tion of the filling body 29 can be carried out for example by filling the moulding cavity 30 with elastomer material introduced by injection or any other manner convenient for a person skilled in the art, after moving cheeks 30a, 30b close to each other.

**[0108]** The above described accomplishment of the inextensible annular structures 4 can advantageously take place close to the toroidal support 11, so that said structures can be directly removed from mould 30a, 30b and laterally applied to the first carcass ply 3 by appropriate mechanical handling devices not described as not of importance to the aims of the invention.

**[0109]** In accordance with a further preferential feature of the invention, accomplishment of the carcass structure 2 further involves formation of at least one second carcass ply 31. Advantageously, this second carcass ply 31 can be formed directly upon the first carcass ply 3 and the inextensible annular structures 4, so that, as clearly shown in Fig. 10, the second annular insert 28 of each annular structure 4 is disposed in contact with an inner surface of the second carcass ply.

**[0110]** In accordance with a possible alternative solution, accomplishment of each annular structure 4 may first involve formation of the first annular insert 27 alone joined to the filling body 29, to carry out application of the second annular insert 28 subsequently to formation of the second carcass ply 31. In this case, each of the inner circumferential portions of the second carcass ply 31 is interposed between the respective filling body 29 and the second annular insert 28, which is applied to the outer surfaces of the second carcass ply itself, in contact relationship therewith.

**[0111]** Preferably the second carcass ply 31 is manufactured in such a manner that it has its respective thread-like elements 32 disposed according to a crossed orientation relative to the thread-like elements 14 belonging to the first carcass ply 3.

**[0112]** In more detail, formation of the second carcass ply 31 conveniently takes place in the same manner as previously described with reference to manufacturing of the first carcass ply 3, i.e. by sequential deposition of respective strip-like lengths 33, to define respective crown portions 34 consecutively disposed in side by side relationship in a circumferential direction and side portions 35 each partly covered by the side portion 35 of the adjacent strip-like length 33. In the accompanying figures, the covering or mutual-superposition regions of the strip-like lengths 33 forming the second carcass ply 31 are denoted by 33a.

**[0113]** Conveniently, the strip-like lengths 33 of the second carcass ply 31 are laid down according to a crossed orientation relative to the strip-like lengths 13 forming the first carcass ply. In addition, it is preferably provided that inclination of the strip-like lengths 33 of the second carcass ply 31, with reference to the equatorial plane X-X, should substantially have the same value as the inclination of the strip-like lengths 13 belonging to the first carcass ply 3.



[0114] In tyres of the radial type, a belt structure 5 is currently applied to the carcass structure 2.

[0115] This belt structure 5 may be made in any manner convenient for a person skilled in the art and in the embodiment shown it essentially comprises a first and a second belt strips 6a, 6b having cords with a respectively crossed orientation. Superposed on the belt strips is an auxiliary belt strip 7, for instance obtained by winding at least one continuous cord in coils axially disposed in side by side relationship on the first and second belt strips 5, 6.

[0116] Then the tread band 8 and sidewalls 9, which are also obtained in any manner convenient for a person skilled in the art, are applied to the belt structure 5.

[0117] Embodiments of a belt structure, sidewalls and a tread band that can be advantageously put into practice for a complete accomplishment of the tyre in reference on the toroidal support 11 are described in the European Patent Application No. 97830632.2 in the name of the same Applicant.

[0118] Tyre 1 as manufactured and after removal of same from support 11, can be now submitted to a vulcanization step that can be carried out in any known and conventional manner.

[0119] According to a possible alternative solution, an air tube of closed tubular section may be advantageously associated with tyre 1 in addition to, or in place of liner 10, before the vulcanization step, which air tube is inserted into carcass 2 after the tyre has been removed from the toroidal support 11. This air tube, not shown in the accompanying drawings, will be inflated after the tyre has been introduced into a vulcanization mould, to supply an inner pressure suitable to ensure a perfect adhesion of the tyre against the mould walls and, in particular, against the mould parts intended for defining the longitudinal and transverse cuts 8a of the tread pattern.

[0120] According to a further preferential feature of the present invention, during the vulcanization step the carcass plies 3, 31 and belt strips 6a, 6b, 7 are submitted to a stretching step to achieve a pre-tensioning thereof, giving rise to a tyre expansion of a linear amount, measured on the circumferential extension at the equatorial plane X-X of the tyre itself, included by way of example between 2% and 5%. This stretching step can be achieved by effect of the inflation pressure of the above mentioned air tube, or other type of inflatable bladder employed in the vulcanization apparatus.

[0121] The present invention achieves important advantages.

[0122] In fact, the tyre in reference can be obtained through manufacture of the different components directly on a toroidal support on which the tyre is gradually formed or in any case very close thereto. In this way all problems connected with manufacture, storage and management of semifinished products which are common to manufacturing processes of the traditional type are eliminated.

[0123] It is to note in particular that formation of the carcass ply or plies by deposition of strip-like lengths each formed of several cords incorporated into one elastomer layer enables important advantages to be achieved. First of all, in comparison with the method described in the above mentioned US Patent 5,362,343, the manufacturing times for each carcass ply can be greatly reduced, due to the simultaneous deposition of as many thread-like elements as they are contained in each strip-like length 13 or in the continuous strip-like element 2a from which lengths 13 come. Employment of the strip-like lengths 13 also dispenses with the need for previously depositing liner 10 onto the toroidal support. In fact, the elastomer layer 17 employed in forming the continuous strip-like element 2a is able by itself of ensuring an efficient adhesion of element 2a to the toroidal support 11, thereby ensuring a steady positioning of the individual lengths 13, 33.

[0124] Accuracy in positioning of the strip-like lengths 13, 33 and thread-like elements integrated therein is further improved by the fact that each strip-like length has an important structural consistency that makes it insensitive to vibrations or similar oscillation effects which can be transmitted by the deposition apparatus 19. In this connection it is to note that deposition of individual cords, as described in US Patent No. 5,362,343, may be somewhat problematic, due exactly to vibrations and/or oscillations undergone by said cords during the deposition step.

[0125] Furthermore, simultaneous deposition of a plurality of thread-like elements in accordance with the invention enables the deposition apparatus 19 to be operated at slower rates than required when deposition of individual cords is concerned, which is a further advantage in terms of working accuracy without on the other hand impairing productivity.

[0126] Besides, deposition of strip-like lengths directly crownwise to a toroidal support of a profile substantially identical with that of the finished tyre enables densities to be achieved that cannot be reached in the art by known methods providing deposition of a carcass ply in the form of a cylindrical sleeve and subsequent shaping of same into a toroidal form, with consequent thinning of the carcass ply cords disposed crownwise to the finished tyre.

[0127] In addition to the above, each strip-like length can be steadily fastened to the toroidal support by a vacuum effect produced through possible suction ducts 26, which steady fastening by vacuum cannot be achieved by known processes carrying out deposition of individual cords.

[0128] If required, the side portions of the strip-like lengths can be disposed at a suitably increased inclination relative to a direction radial to the toroidal support axis, which will enable the expansion undergone by the tyre during the stretching step imposed to it on vulcanization to be efficiently helped. In fact, during this step, the side portions 25, 35 tend to take an orientation in a

plane radial to the tyre together with the crown portions 24, 34 extending between the side portions.

[0129] The construction and structure conception of the subject tyre, particularly with reference to its carcass structure 2, enables important improvements to be achieved in terms of structural strength, in particular close to the sidewalls and beads, where a greater structural strength is usually required, as well as in terms of behaviour, particularly in connection with the effects of the slip thrusts that occur when tyres are run on bends.

[0130] In fact, it is to note that, even if each carcass ply 3, 31 is taken into account separately from the other carcass ply, the mutual superposition or partial covering of the strip-like lengths 13, 33 gives rise to a first structural strengthening at the tyre sidewall regions. This strengthening is also promoted by the fact that, as above described, in the regions of mutual superposition of the strip-like lengths 13, 33, the thread-like elements 14, 32 belonging to the two lengths are disposed in mutually-crossed orientations.

[0131] The mutually-crossed orientation of the strip-like lengths 13, 33 forming the first and second carcass plies 3, 31 respectively constitutes a second strengthening factor for carcass structure 2. This second strengthening factor is partly by the mutually-crossed arrangement provided for the thread-like elements 14, 32 belonging to the first and second carcass plies 3, 31 respectively, and partly results from the mutually-crossed arrangement provided for the covering or superposition regions 13a, 33a of lengths 13, 33 belonging to the first and second carcass plies.

[0132] This crossed arrangement of the superposition regions 13a, 33a is clearly shown in Fig. 11. From said figure it can be easily understood that the mutual-superposition regions 13a, 33a belonging to the first and second carcass plies 3, 31 respectively, define a type of network structure giving the tyre an exceptional structural strength. In particular, in this manner qualities such as resistance to accidental impacts against pavement borders or the like for example, and tyre resistance to torsional stresses around the rotation axis are improved, which will make the tyre appropriate to withstand high torque values both during acceleration and braking.

[0133] In addition to the above, the construction features of the inextensible annular structures 4 are suitable to further increase the structural strength of the tyre at the bead and sidewall regions.

[0134] In fact, the presence of the circumferentially inextensible annular inserts 27, 28 intimately joined to the carcass plies 3, 31 creates a further "bond" between the mutually-crossed thread-like elements 14, 32 belonging to the first and second carcass plies 3, 31. Thus, the carcass structure 2 is further strengthened at the regions corresponding to the tyre beads without requiring for the purpose employment of additional strip-like inserts, usually called "flippers", wound like a slip-knot around the inextensible annular structures 4, said

flippers being used on the contrary in the known art.

[0135] From a comparison between Figs. 12 and 13 it can be easily noticed the improvement produced by the construction expedients described above in connection with the tyre behaviour under the effect of slip thrusts directed axially of the tyre, generated when the tyre is run on a bend, for example. For the sake of clarity, section dashing has been intentionally omitted from the tyres shown in Figs. 12 and 13. It is also to point out that, for better highlighting the phenomena triggered by the slip thrusts, Figs. 12 and 13 have been made with reference to tyres under conditions of partial deflation.

[0136] In more detail, Fig. 12 shows a tyre 101 of the traditional type, mounted on a respective rim 100 that, at each tyre bead, has a bead seat 100a axially delimited by a flange 100b defining an outer side edge of the rim and a security hump 100c. The different components of tyre 101 are marked by numeric indices obtained by adding 100 to the numeric value of the indices previously employed for corresponding parts of tyre 1 in accordance with the invention.

[0137] In tyre 101 made in accordance with the known art, the carcass ply or plies tend to bend at the tyre sidewall under the effect of the slip thrust T, generated parallelly to the rotation axis of the tyre by friction of the tread band 108 on the ground, during a bend.

[0138] This slip thrust T, transmitted along the ply or plies 103 of the carcass structure 102 up to the inextensible annular structures 104, generates a radial component Tr and an axial component Ts. The radial component Tr is counteracted by the circumferential inextensibility of the annular structure 104 resting, over the whole circumferential volume thereof, on the respective seat 100a provided in rim 100. The axial component Ts, oriented towards the equatorial plane of the tyre, tends to move the tyre bead away from the flange 100b of rim 100 and is usually counteracted by the security hump 100c. The radial sizes of the security hump are however rather limited and it may easily happen that, when the axial component Ts exceeds given values, the tyre bead is removed from its respective seat 100a, instantaneously causing a full deflation and a consequent loss of functionality of tyre 100. This phenomenon is also facilitated by the fact that the tyre bead structured in accordance with the known art, under the effect of the slip thrust T, tends to "roll" on the security hump 100c.

[0139] The risks that the above described phenomenon of removal of the bead from its seat may occur are particularly important when the tyre is forced to run under conditions of partial deflation, and the carcass structure 102 is therefore subjected to undergo important deformations under the effect of the slip thrusts.

[0140] Referring now to the tyre in reference shown in Fig. 13, the annular structures 4 of the invention, interposed between the first and second carcass plies 3, 31, prevent the tyre beads from rotating, under the effect of the slip thrust T, around their resting point against the

respective security humps 100c provided in rim 100.

[0141] In more detail, it is to note that the presence of the circumferentially inextensible annular inserts 27, 28 located internally of, and directly in contact with the respective carcass plies 3, 31 and mutually spaced apart by interposition of the filling body 29, efficiently prevents the bead from bending and rotating under the effect of slip thrusts. In fact, on examining Fig. 13 it can be seen that the slip thrust T would tend to bend the inextensible annular structure 4 towards the equatorial plane of tyre 1. Under this circumstance, the first annular insert 27 tends to be radially compressed, whereas the second annular insert 28 is subjected to a tensile stress in a radial direction. However, the circumferential inextensibility of the individual coils 27a, 28a forming inserts 27, 28, as well as the intimate union of said inserts with the respective carcass plies 3, 31 having the respective thread-like elements 14, 32 mutually crossed at the superposition regions 13a, 33a, inhibit the capability of bending deformation of the inextensible annular structure 4 almost completely.

[0142] The slip force T is equably shared between the first and second carcass plies and transmitted along said plies until the respective first and second inextensible annular elements 27, 28 provided in structure 4.

[0143] Under this situation the portion of the slip force T transmitted along the first carcass ply 3 until a region close to the first annular insert 27 gives rise to a radial component  $Tr_1$  tending to move the bead away from the bead seat 100a and counteracted by the circumferential inextensibility of the annular structure 4, as well as to an axial component  $Ts_1$  tending to push the bead against the circumferential flange 100b, thereby ensuring maintenance of a steady positioning of said bead.

[0144] The slip force T portion transmitted along the second carcass ply 31 generates a radial component  $Tr_2$  as well, which is counteracted by the circumferential inextensibility of the second annular insert 28, and an axial component tending to push the bead against the flange 100b but which has a practically zero value when, as in the case shown, the inner circumferential edge of the second carcass ply takes an orientation perpendicular to the axis of the tyre 1.

[0145] A correct positioning of the bead is in any case ensured by the above described axial component  $Ts_1$ .

[0146] In this way the tyre having beads made in accordance with the present invention can bear the so-called "J-curve Test" without removal of the bead from its seat until inflation pressures of 0.5 bar, whereas in the known art tyres that are unable to counteract bead displacements from their seats at pressures lower than 0.8-1.0 bar are considered as acceptable.

[0147] It is also to note that the annular inserts 27 and 28 furnish a further structural protection of the tyre at the beads.

[0148] Increase in the structural strength at the sidewalls has been advantageously obtained without involving an excessive stiffening at the carcass structure

crown, where the lengths of each ply are circumferentially disposed in side by side relationship in the absence of mutual superposition. This aspect is particularly advantageous with reference to high-performance lowered-profile tyres where the structural strength of the sidewalls is greatly critical, also due to the high torque values that the tyre must be able to transmit.

## Claims

1. A method of making a tyre, said tyre comprising:

- a carcass structure (2);
- a tread band (8) at a position circumferentially external to the carcass structure (3); and
- at least one pair of sidewalls (9) at laterally opposite positions on the carcass structure (2); characterized in that accomplishment of the carcass structure (2) involves formation of at least one first carcass ply (3) by the following steps:
  - preparing strip-like lengths (13), each comprising longitudinal and parallel thread-like elements (14) at least partly coated with at least one layer of raw elastomer material (17);
  - depositing each of the strip-like lengths (13) onto a toroidal support (11) in a substantially U-shaped conformation around the cross section profile of the toroidal support (11), to define two side portions (25) substantially extending in planes orthogonal to a geometric axis of rotation of the toroidal support (11) at mutually spaced apart positions in an axial direction, and a crown portion (24) extending at a radially outer position between the side portions (25), wherein the crown portions (24) of each strip-like length (13) are consecutively disposed in side by side relationship along the circumferential extension of the toroidal support (11), whereas the side portions (25) of each strip-like length (13) are each partly covered with a side portion of at least one circumferentially consecutive length.

2. A method as claimed in claim 1, wherein preparation of said strip-like lengths (13) is carried out by cutting actions sequentially executed on at least one continuous strip-like element (13a) incorporating said thread-like elements (14) in said layer of raw elastomer material (17).
3. A method as claimed in claim 1, wherein each cutting action is followed by deposition of the individual length (13) thus obtained onto the toroidal support (11).
4. A method as claimed in claim 1, wherein the side portions (25) belonging to circumferentially contiguous

ous strip-like lengths (13) on the toroidal support (11) are caused to mutually converge towards the geometric axis of rotation of the toroidal support itself.

5 5. A method as claimed in claim 1, wherein covering of the side portions (25) of each strip-like length (13) progressively decreases starting from a maximum value at radially inner ends of the side portions until a zero value at transition regions between said side portions and crown portions (24).

10 6. A method as claimed in claim 1, wherein the individual strip-like lengths (13) are sequentially deposited onto the toroidal support (11) according to a circumferential distribution pitch corresponding to the width of the strip-like lengths.

15 7. A method as claimed in claim 1, wherein the individual strip-like lengths (13) are sequentially deposited onto the toroidal support (11) according to a circumferential distribution pitch corresponding to a multiple of the width of the strip-like lengths.

20 8. A method as claimed in claim 1, wherein each strip-like length (13) has a width corresponding to a submultiple of the circumferential extension of the toroidal support (11), as measured at an equatorial plane thereof.

25 9. A method as claimed in claim 1, wherein accomplishment of said at least one first carcass ply (3) further involves a step of sequentially pressing each strip-like length (13) at its side portions (25), to define regions of increased width close to the inner circumferential edges of the carcass structure (2).

30 10. A method as claimed in claim 9, wherein preparation of said strip-like lengths (13) is carried out by cutting actions sequentially executed on at least one continuous strip-like element (2a) incorporating said thread-like elements (14) in said layer of raw elastomer material (17), said pressing step being carried out on the continuous strip-like element (2a) before execution of the cutting action.

35 11. A method as claimed in claim 9, wherein concurrently with said pressing step, moving apart from each other of the thread-like elements (14) comprised in the strip-like length (13) is carried out.

40 12. A method as claimed in claim 1, wherein during the deposition step, at least one of the strip-like lengths (13) is held on the toroidal support (11) by a suction action produced through the toroidal support itself.

45 13. A method as claimed in claim 1, wherein deposition

of each strip-like length (13) involves the steps of:

- laying down the strip-like length (13) transversely and at a centred position relative to an equatorial plane of the toroidal support (11);
- radially moving the strip-like length (13) close to the toroidal support (11) so as to form the crown portion (24) of the length on the toroidal support itself;
- translating the opposite ends of the strip-like length (13) substantially radially close to the geometric axis of rotation of the toroidal support (11) for applying the side portions (25) of the strip-like length (13) on the toroidal support (11);
- rotating the toroidal support (11) through an angular pitch corresponding to the circumferential distribution pitch of the strip-like lengths (13).

14. A method as claimed in claim 1, further comprising a step of pressing said side portions (25) of the strip-like lengths (13) against the side walls of the toroidal support (11).

15. A method as claimed in claim 1, wherein accomplishment of the carcass structure (2) further comprises the step of applying at least one inextensible annular structure (4) to a region close to each of the inner circumferential edges of the carcass ply (3) obtained from the deposition step.

16. A method as claimed in claim 1, wherein accomplishment of the carcass structure (2) further comprises the step of forming at least one second carcass ply (31) superposed on the first carcass ply (3).

17. A method as claimed in claim 16, wherein formation of the second carcass ply (31) takes place in the same manner as accomplishment of the first carcass ply (3).

18. A method of making a tyre provided with:

- a carcass structure (2) having a pair of circumferentially inextensible annular structures (4) each disposed in a region close to a radially inner circumferential edge of said carcass structure (2);
  - a tread band (8) applied to the carcass structure at a circumferentially external position thereof;
  - at least one pair of sidewalls (9) located at laterally opposite positions on the carcass structure (2);
- characterized in that accomplishment of each inextensible annular structure (4) comprises

the steps of:

- depositing at least one first elongated element in concentric coils (27a) into a moulding cavity (30) in view of forming a first circumferentially inextensible annular insert (27) substantially in the form of a crown;
- depositing at least one second elongated element in concentric coils (28a) into the moulding cavity (30) in view of forming a second circumferentially inextensible annular insert (28) substantially in the form of a crown concentrically disposed in side by side relationship relative to the first annular insert (27);
- forming at least one filling body (29) of raw elastomer material in the moulding cavity (30), which filling body is interposed between, and intimately joined to the first and second circumferentially inextensible annular anchoring elements (27, 28).

19. A method as claimed in claim 18, wherein each of said inextensible annular structures (4) is interposed between at least one first carcass ply (3) and one second carcass ply (31) superposed on said first carcass ply.

20. A method as claimed in claim 18, wherein the deposition step of at least one of said first and second elongated elements is preceded by a rubberizing step in which the elongated element is coated with at least one layer of raw elastomer material.

21. A method as claimed in claim 18, further comprising a step of magnetically retaining at least one of said first and second circumferentially inextensible annular inserts (27, 28), at a predetermined position, within the moulding cavity (30).

22. A method as claimed in claim 18, wherein formation of said filling body (29) comprises the steps of:

- interposing at least one annular element of raw elastomer material of a predetermined volume between the first and second inextensible annular inserts (27, 28);
- reducing the volume of the moulding cavity (30) in order to compress said annular element of elastomer material between the first and second inextensible annular inserts (27, 28) and deform it until it fills said moulding cavity.

23. A method as claimed in claim 1, wherein formation of the carcass structure (2) is preceded by a step of coating the toroidal support (11) with at least one liner (10) made of an air-proof elastomer material.

24. A method as claimed in claim 23, wherein said coating step is carried out by winding at least one

ribbon-like band (12) of an air-proof elastomer material in coils disposed in side by side relationship along the cross-section profile of the toroidal support (11).

25. A method as claimed in claim 1, further comprising the steps of:

- disengaging the tyre (1) from the toroidal support (11);
- introducing an air tube into the carcass structure (2);
- vulcanizing the tyre (1).

26. A method as claimed in claim 1, further comprising a vulcanization step during which stretching of said carcass plies (3) and belt strips (6, 7) is carried out for achieving an expansion of the tyre of a linear amount included between 2% and 5%.

FIG. 1

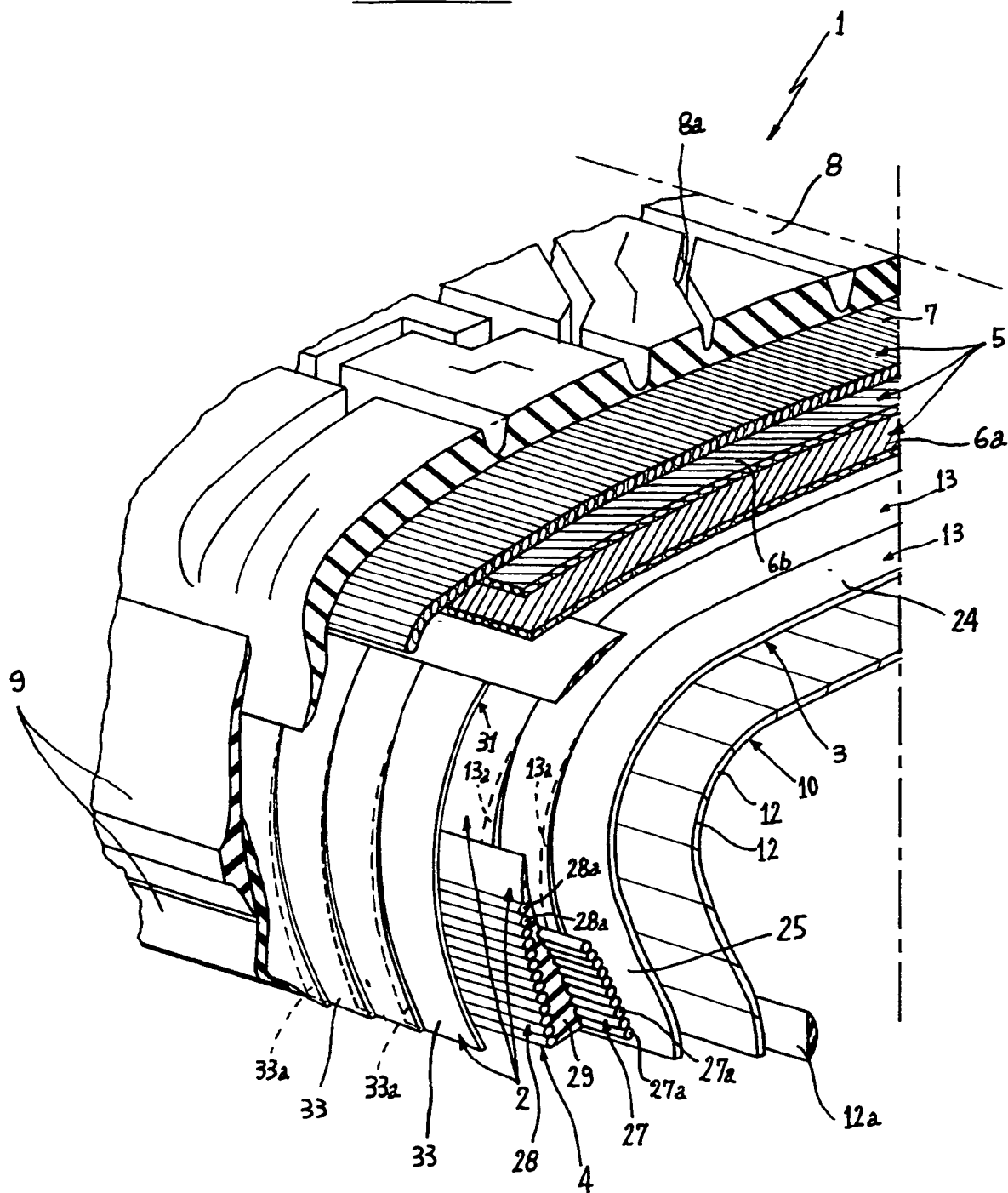


FIG. 2

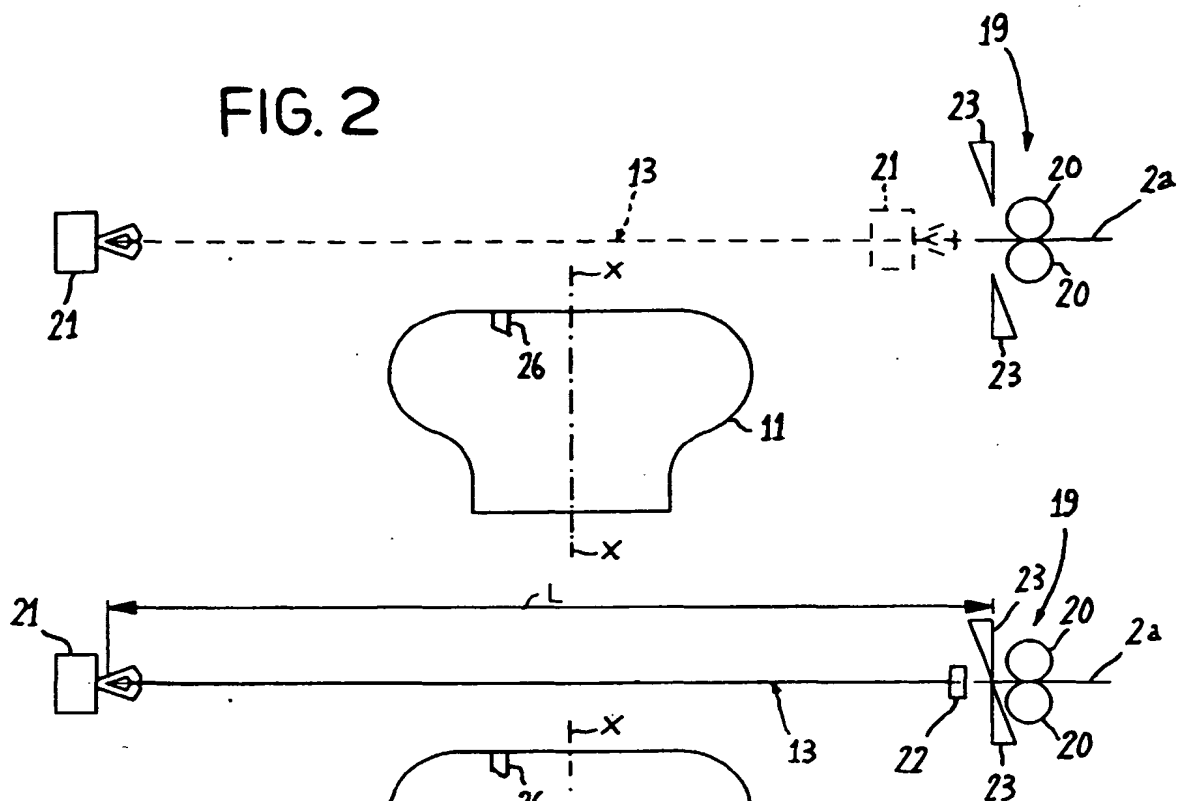


FIG. 3

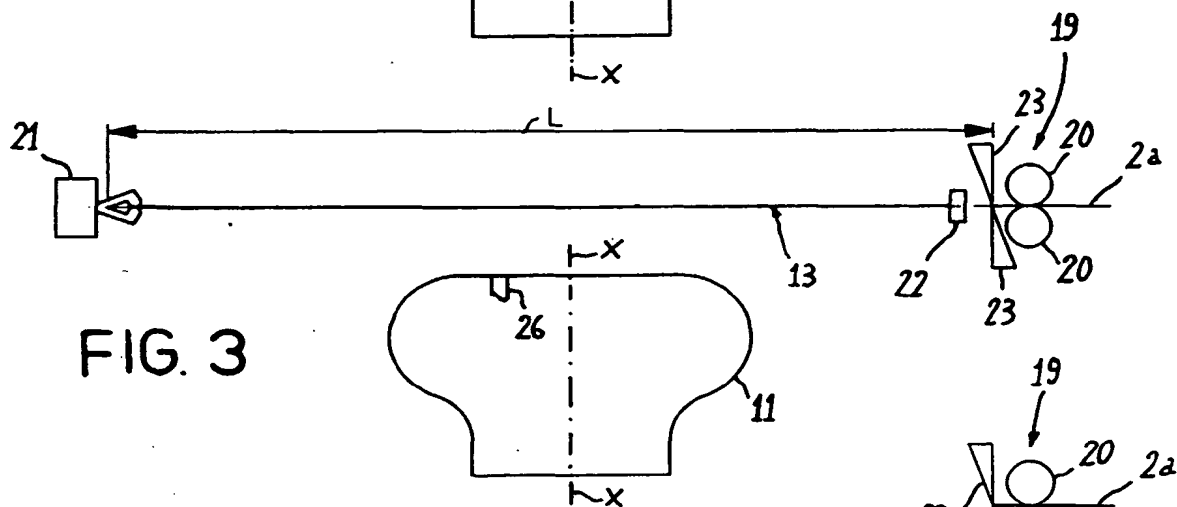


FIG. 4

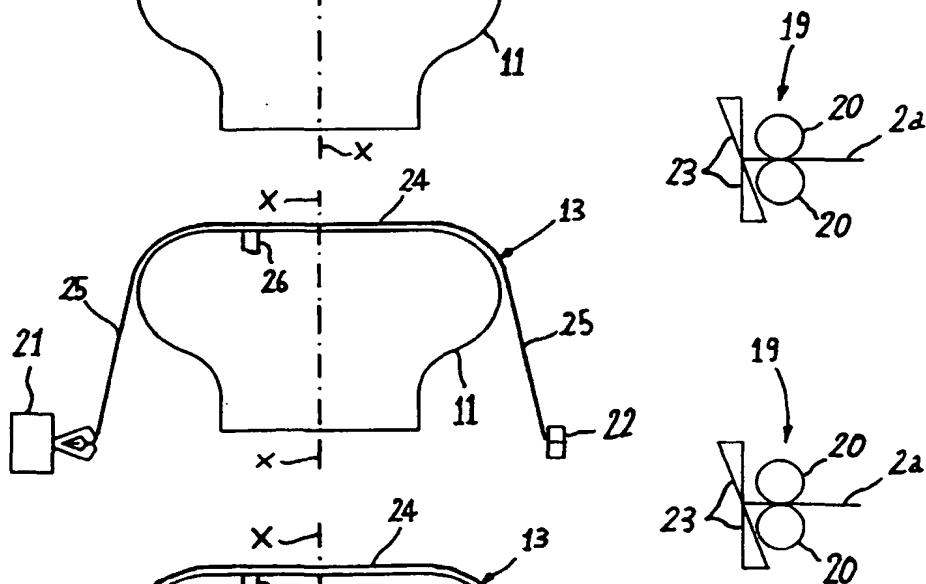
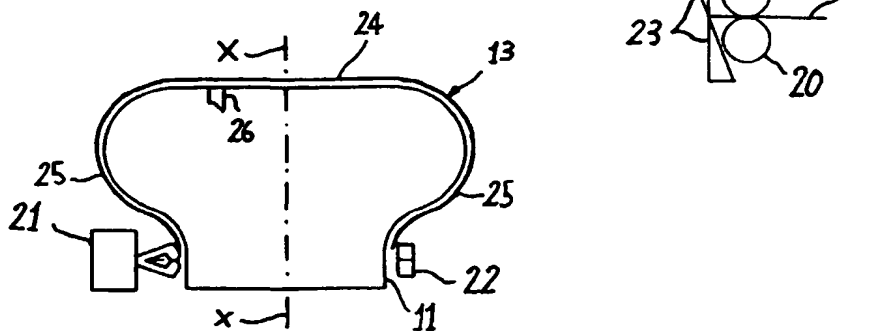
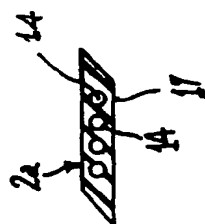
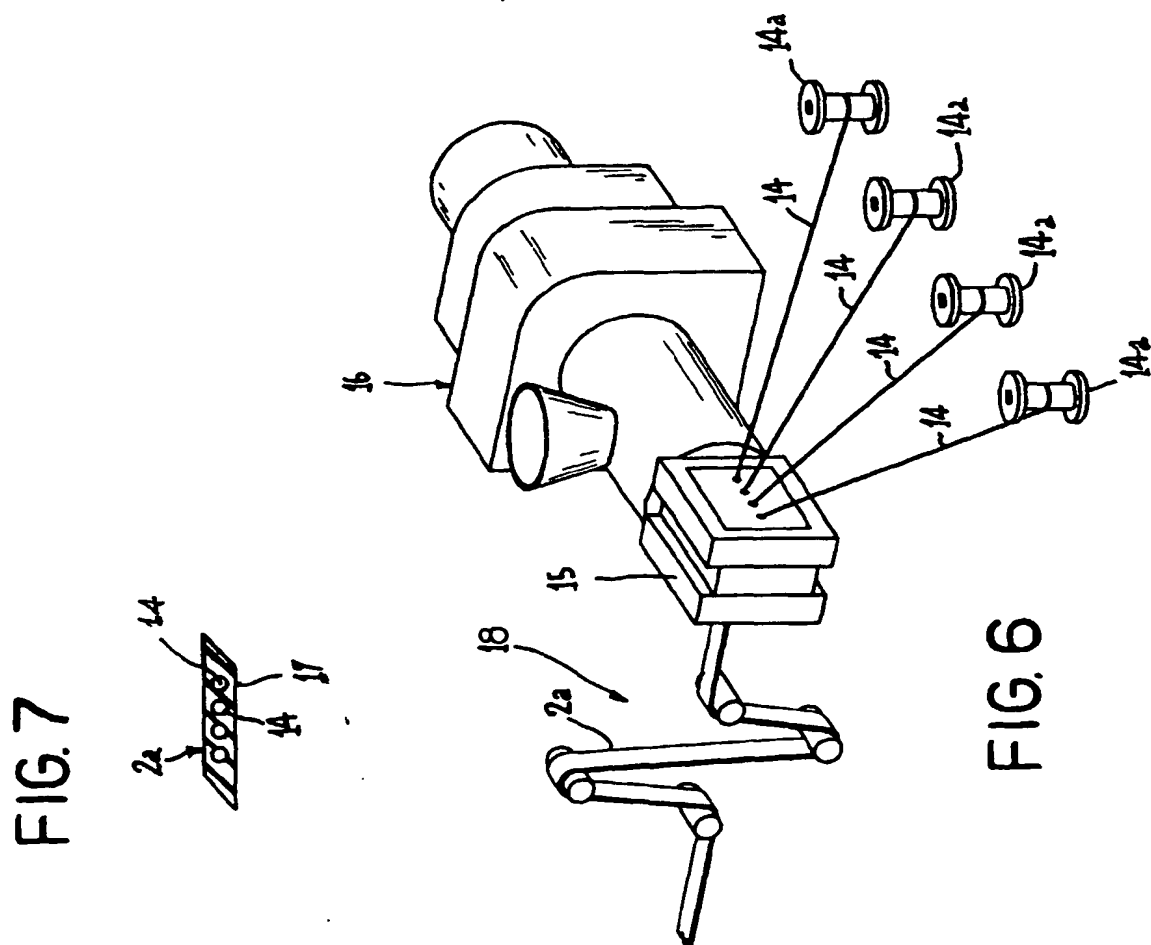
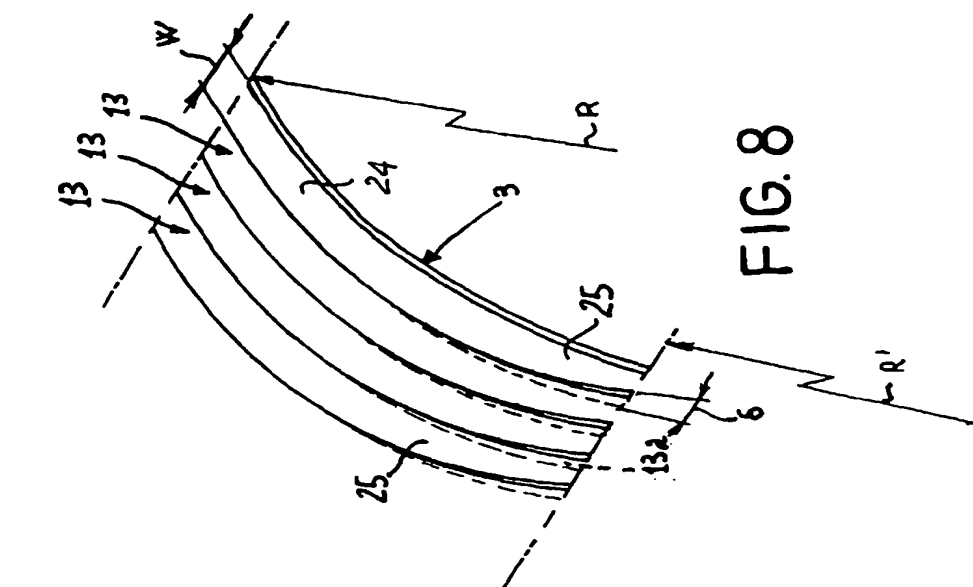


FIG. 5







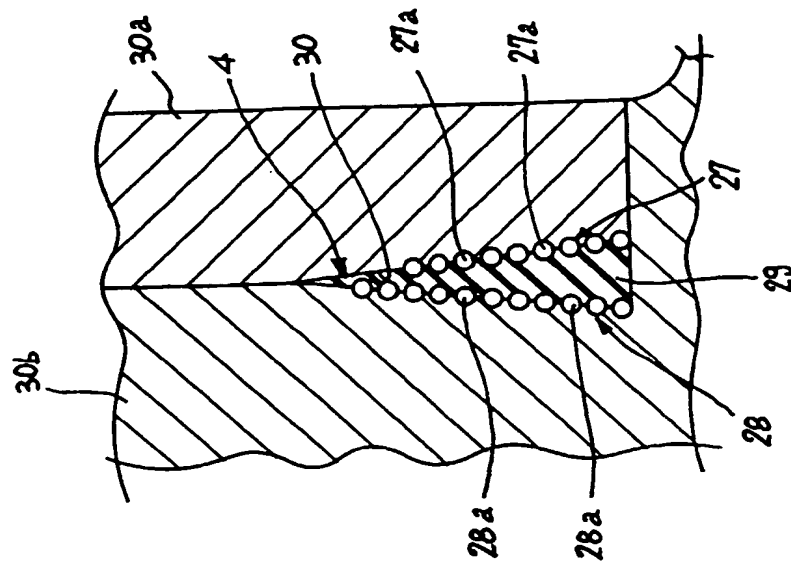


FIG. 9

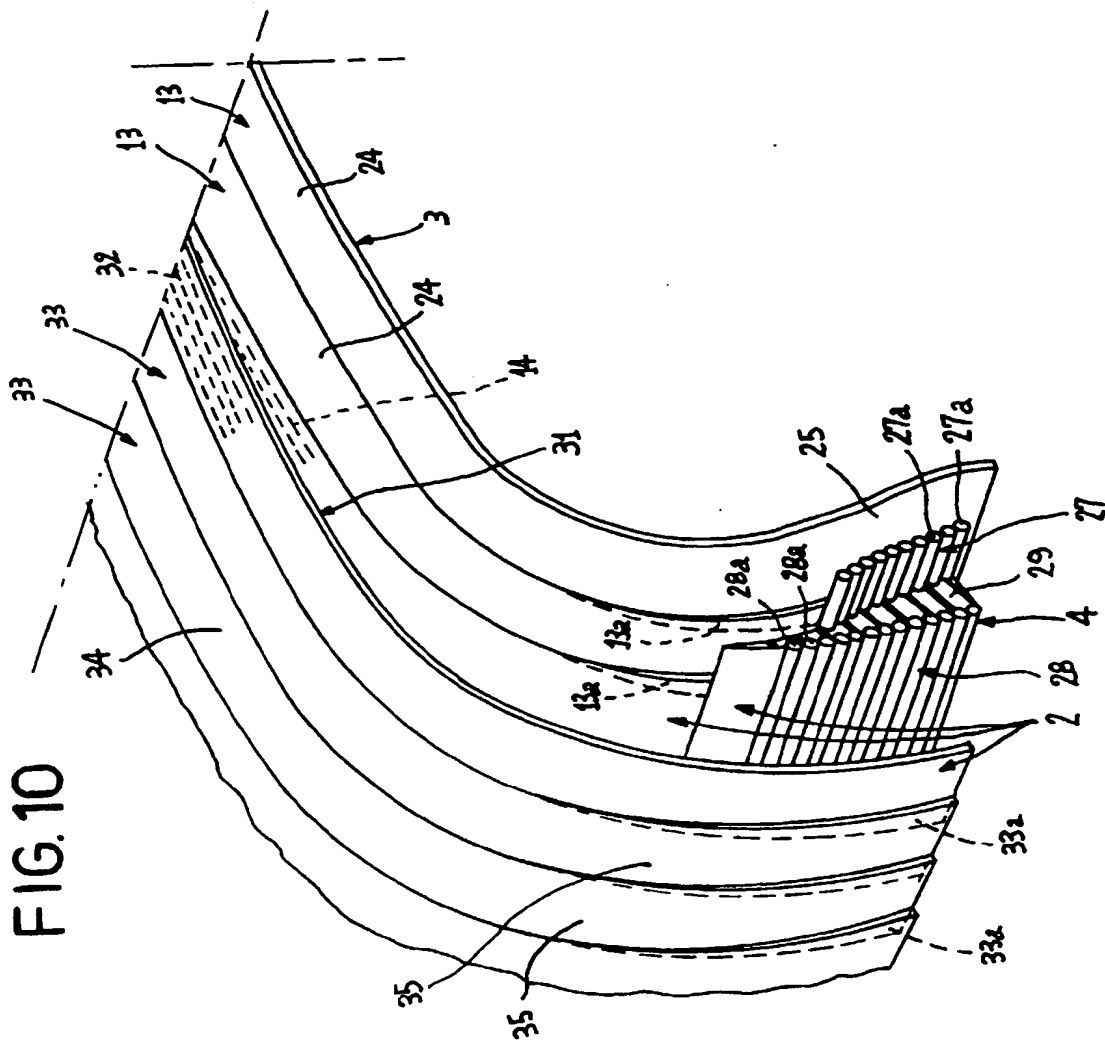
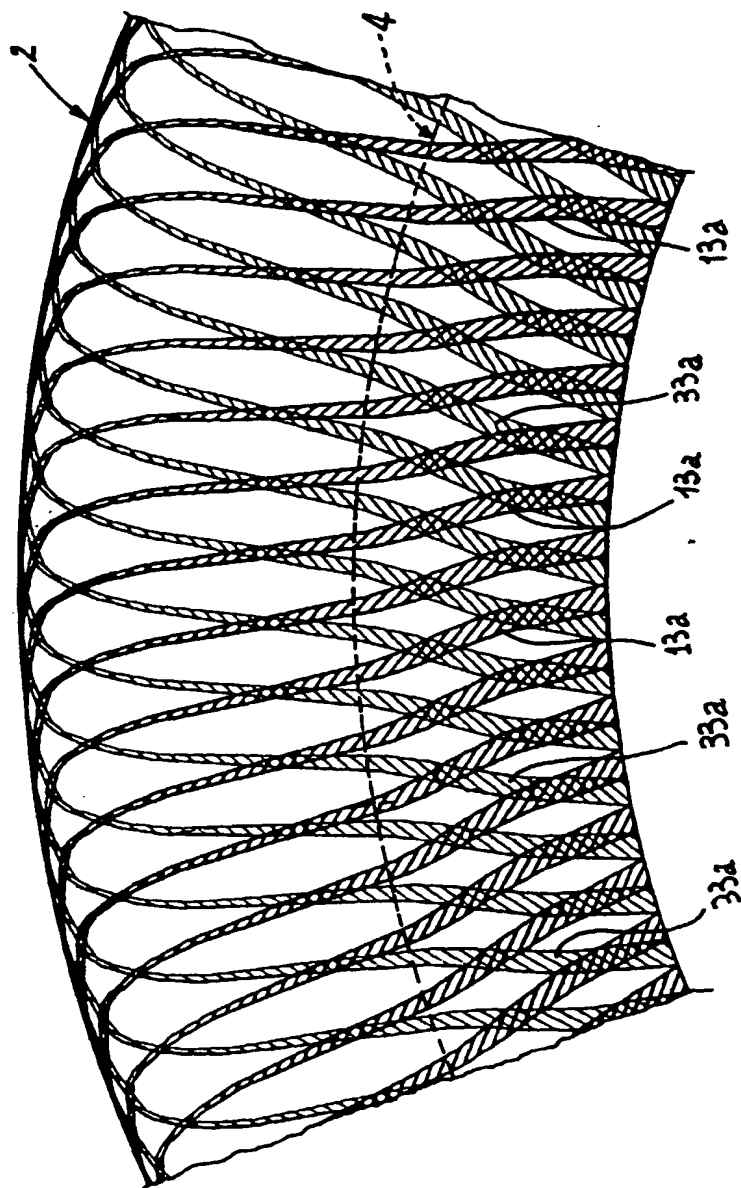
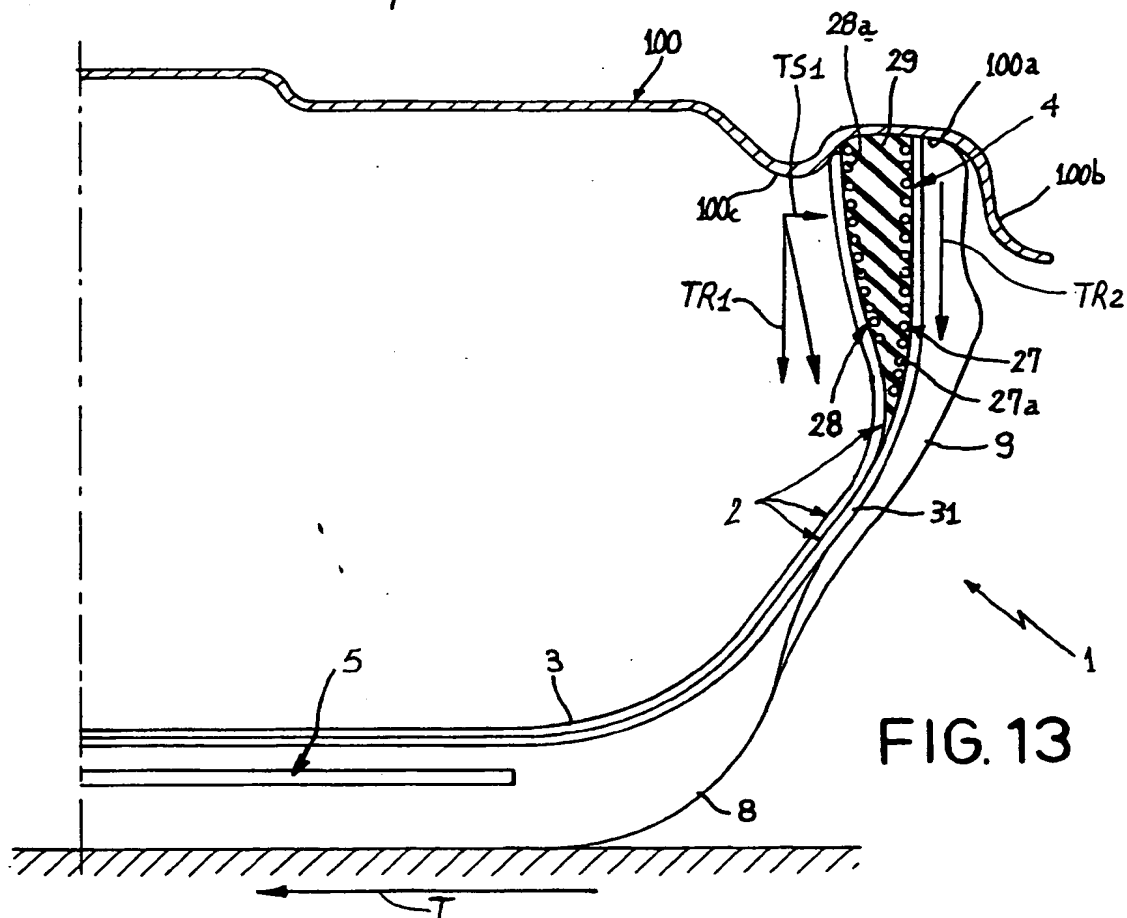
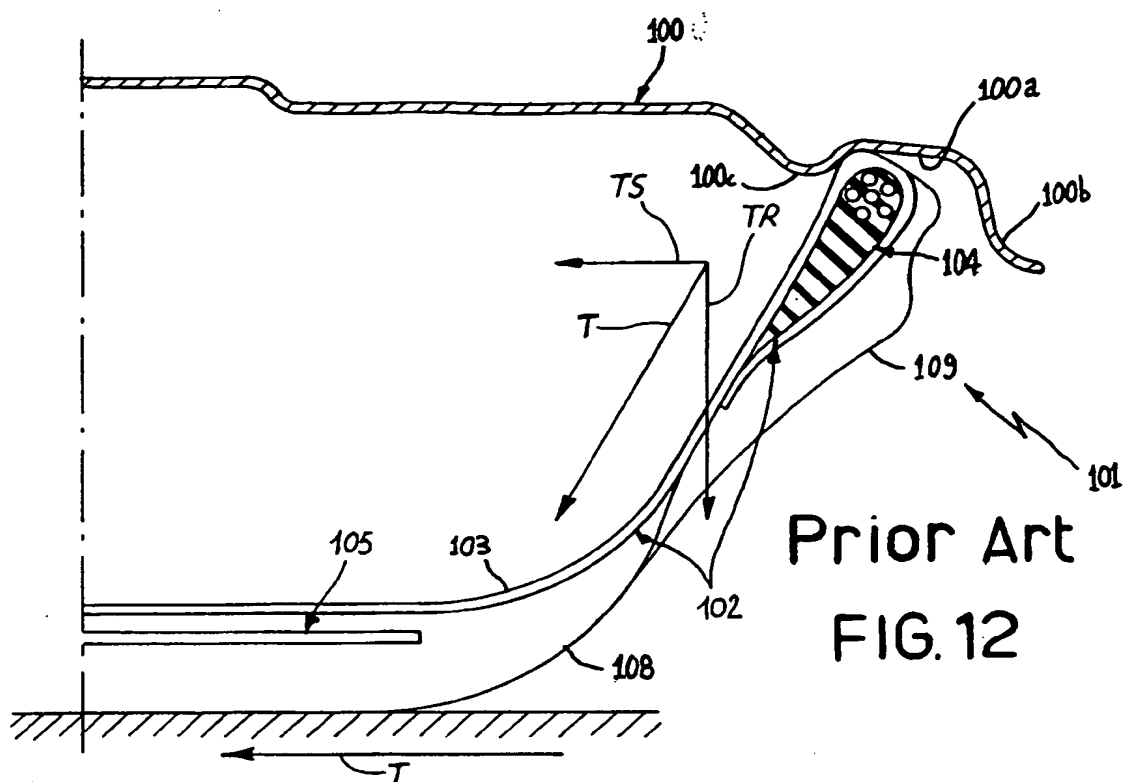


FIG. 10

FIG. 11







European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 97 83 0731

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR 384 231 A (H. LEVIEUZE ET AL.) * the whole document *	1,3-6,8, 14,15	B29D30/16 B29D30/48
X Y	US 4 248 287 A (CHRISTMAN HAROLD E) 3 February 1981 * column 4, line 42 - column 5, line 47; figures 7-18 *	1,3-6,8, 14-17,23 2,10,13, 14	
Y	FR 1 317 045 A (DUNLOP RUBBERCOMP.) 29 April 1963 * page 2, column 2, line 12 - line 24; figures 1-8 * * page 5, column 1, line 29 - page 6, column 1, line 3 *	2,10,13, 14	
A	EP 0 780 221 A (BRIDGESTONE CORP) 25 June 1997 * column 12, line 31 - column 13, line 6; figures 24-26 * * claims 1,12,14 *	1-4,6,8, 13-15	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B29D B60C
A	EP 0 557 615 A (BRIDGESTONE CORP) 1 September 1993 * column 8, line 16 - line 30; figure 9 * * claims 1,8 *	1-4,6,8, 13-15	
A	US 1 350 995 A (H. E. GRABAU) 24 August 1920 * page 1, line 97 - page 2, line 6; figures 1,2,7,8 * * page 2, line 52 - line 72 *	1,3-5, 13,15	
A	US 1 728 957 A (F. S. DICKINSON) 24 September 1929 * the whole document *	1-3,6,8, 9,13-17	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 3 September 1998	Examiner Fregosi, A
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03 82 (P4/C01)



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# EUROPEAN SEARCH REPORT

Application Number  
EP 97 83 0731

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cls)
A	US 4 144 006 A (M. IUCHI) 13 March 1979 * column 1, line 5 - line 37; figures 1-4 *	25	
A	US 5 171 394 A (D. LAURENT) 15 December 1992 * the whole document *	24	
A	EP 0 664 232 A (SEDEPRO) 26 July 1995 * the whole document *	18-20	
A	DATABASE WPI Week 8539 Derwent Publications Ltd., London, GB; AN 85-240322 XP002076434 & JP 60 157 840 A (SUMITOMO), 19 August 1985 * abstract; figures 1-4 *	18,22	
A	US 4 168 193 A (J.-P. BRUNET ET AL.) 18 September 1979 * the whole document *	18,22	
A	DATABASE WPI Week 9004 Derwent Publications Ltd., London, GB; AN 90-027261 XP002076435 & JP 01 306 233 A (TOYO RUBBER), 11 December 1989 * abstract; figure 1 *	18,20	TECHNICAL FIELDS SEARCHED (Int.C1.6)
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>3 September 1998</b>	Examiner <b>Fregosi, A</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03/82 (P4/C01)



European Patent  
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Application Number  
EP 97 83 0731

**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

**LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



European Patent  
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**LACK OF UNITY OF INVENTION  
SHEET B**

Application Number  
EP 97 83 0731

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

**1. Claims: 1 - 17, 23 - 26**

Method of manufacturing a pneumatic tyre comprising the step of manufacturing its carcass by depositing lengths of strip-like reinforcing elements onto a toroidal support in side by side deposition arrangement.

**2. Claims: 18 - 22**

Method of manufacturing a pneumatic tyre in which an inextensible annular structure is manufactured in a mould.

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 97 83 0731

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
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03-09-1998

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
FR 384231	A		NONE	
US 4248287	A	03-02-1981	NONE	
FR 1317045	A	29-04-1963	NONE	
EP 0780221	A	25-06-1997	US 5705007 A CA 2193452 A JP 9183169 A	06-01-1998 22-06-1997 15-07-1997
EP 0557615	A	01-09-1993	JP 6155631 A	03-06-1994
US 1350995	A	24-08-1920	NONE	
US 1728957	A	24-09-1929	NONE	
US 4144006	A	13-03-1979	JP 53102982 A DE 2807365 A FR 2380868 A	07-09-1978 31-08-1978 15-09-1978
US 5171394	A	15-12-1992	FR 2603841 A US 5221406 A AU 601216 B AU 7862787 A CA 1327683 A CN 1016408 B DK 486687 A,B, EG 18347 A EP 0264600 A FI 874064 A,B IE 60747 B IN 170097 A JP 2070282 C JP 7094155 B JP 63089336 A KR 9507772 B MX 170597 B OA 8659 A PH 26881 A PT 85748 B	18-03-1988 22-06-1993 06-09-1990 24-03-1988 15-03-1994 29-04-1992 18-03-1988 30-10-1992 27-04-1988 18-03-1988 10-08-1994 08-02-1992 10-07-1996 11-10-1995 20-04-1988 18-07-1995 01-09-1993 30-11-1988 16-11-1992 30-07-1993

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EP 97 83 0731

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The members are as contained in the European Patent Office EDP file on  
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03-09-1998

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5171394 A		US 4963207 A	16-10-1990
EP 664232 A	26-07-1995	FR 2715349 A	28-07-1995
		BR 9500262 A	17-10-1995
		CN 1112870 A	06-12-1995
		DE 69502116 D	28-05-1998
		JP 7215007 A	15-08-1995
		US 5660656 A	26-08-1997
US 4168193 A	18-09-1979	FR 2355648 A	20-01-1978
		DE 2728333 A	05-01-1978
		GB 1560052 A	30-01-1980
		JP 53000270 A	05-01-1978

EPO FORM P459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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